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METHOD AND DISTANCE DETECTING DEVICE FOR
DETECTING THE PROJECTED DISTANCE BETWEEN
A DISTANCE MEASURING DEVICE AND AN OBSTACLE

Description

The invention concerns a method for detecting the projected distance between a distance measuring device, which is preferably installed in a vehicle, and an obstacle. The invention also concerns a computer program including a program code and a distance detecting device for performing this method.

Methods and devices of this type are known in the art. Any obstacle has one nearest point on the surface of the obstacle in the vicinity of the distance measuring device, having the shortest projected distance from the distance measuring device of all points on the obstacle. This shortest projected distance is detected by conventional methods and devices, when and for as long as the nearest point is within the detecting range of the distance measuring device. Distance measuring devices, which are installed e.g. in vehicles, with horizontal orientation and a conical detecting range, bear the risk that obstacles having a maximum height, which is smaller than the height of the installation position of the distance measuring device, disappear from the conical detecting range below a certain minimum separation.

Departing therefrom, it is the underlying purpose of the invention to provide a method for detecting the shortest projected distance between a distance measuring device and an obstacle, a computer program and a distance detecting device for performing this method, which permit

calculation of the shortest projected distance even when this point is outside of the detecting range of the distance measuring device.

This object is achieved by the method claimed in claim 1. This method is characterized by the following steps: Storing a limit time when the nearest point of the obstacle disappears from the detecting range of the distance measuring means as the distance measuring device and the obstacle approach each other; storing a projected limit distance between the nearest point of the obstacle and the distance measuring device at the limit time; and detecting the projected distance between the nearest point of the obstacle and the distance measuring device, thereby taking into consideration the limit distance, the limit time and information about the relative motion between the distance measuring device and the obstacle as long as the nearest point of the obstacle is outside of the detecting range of the distance measuring device.

The claimed method advantageously permits calculation of the respectively shortest projected distance between the obstacle and the distance measuring device even when the nearest point on the surface of the obstacle is outside of the detecting range of the distance measuring device. This calculation can be performed in accordance with the invention when a limit distance, a limit time and information about the relative motion between the distance measuring device and the obstacle are known. The nearest point of the obstacle is that point on the surface of the obstacle which has the shortest projected distance from the distance measuring device of all points of the obstacle. Projected distance thereby designates the length of projection of the direct separation between the nearest point P and the distance measuring device along a horizontal line. The terms limit time and limit distance used in the present invention have the meanings defined in the previous paragraph.

The distance and, in particular, the projected distance between the nearest point P and the distance measuring device is advantageously determined on the basis of information about the position and, in particular, about the height of the nearest point above ground. This information about the position or height is determined e.g. by a distance detecting device as long as the nearest point of the obstacle is still within the detecting range of the distance measuring device.

Further advantageous embodiments of the method are the subject matter of the dependent claims.

The above-mentioned object of the invention is also achieved by a computer program including program code and a distance detecting device. The advantages of these two solutions correspond to the advantages mentioned above with respect to the claimed method.

The description includes a total of two figures, wherein

Fig. 1 shows the structure of an inventive distance detecting device;

Fig. 2a shows detection of the distance between a nearest point P and a distance measuring device when the nearest point is within the detecting range of the distance detecting device;

Fig. 2b shows calculation of the projected distance between the nearest point P and the distance measuring device when the nearest point is at the edge of the detecting range; and

Fig. 2c shows determination of the projected distance between the nearest point P and the distance detecting device if the nearest

point P is outside of the detecting range of the distance detecting device.

The invention is explained in more detail below by embodiments with reference to the figures and their descriptions.

Fig. 1 shows the structure of the inventive distance detecting device 100. It is preferably disposed in a vehicle 50 at a level of h_s above ground or above a road (Fig. 2a). It comprises a distance measuring device 110, e.g. in the form of an ultrasound or radar sensor for detecting the distance between the distance measuring device 110 and an obstacle 200 in the vicinity of the distance measuring device 110. The invention is based on the assumption that the maximum height h_p of the obstacle 200 above ground or above the road surface (Fig. 2b) is less than the height h_s of the installation position of the distance measuring device 110 in the vehicle 50. This precondition must be met since only then it is ensured that a nearest point P of the obstacle 200 having the shortest projected distance of all points of the obstacle from the distance measuring device 110, can lie between the nearest point and the distance measuring device 110 and also within or outside of the detecting range of the distance measuring device, depending on the size of the actual distance.

The distance detecting device 100 also comprises a first storage element 120 for storing a limit time when the nearest point P of the obstacle 200 exits the detecting range of the distance measuring device 110 as the distance measuring device 110 approaches the obstacle 200. The distance detecting device 100 also comprises a second storage element for storing a projected limit distance d_{Gr} between the nearest point P of the obstacle 200 and the distance measuring device 110 at the limit time.

The distance detecting device moreover comprises a distance determination means 140 to detect distance information about relative motion between the distance measuring device 110 and the obstacle 200, in particular, after the limit time, i.e. when the nearest point P of the obstacle 200 is outside of the detecting range of the distance measuring device 110. This distance determination means is preferably installed in a vehicle 50 together with all of the components of the distance detecting device 100 described above. This is especially reasonable when the vehicle is movable and an immovable stationary obstacle is detected. The overall distance detecting device and, in particular, the overall distance determination means may be disposed in the obstacle 200 or be distributed between the vehicle 50 and the obstacle 200. It is only important that the distance determination means is designed and arranged to detect relative motion between the distance measuring device 110 and the obstacle 200 irrespective of whether the distance measuring device 110, the obstacle 200 or both move relative to each other. The distance detecting device finally also comprises a calculating means 150 for detecting the projected distance d between the nearest point P of the obstacle 200 and the distance measuring device 100. This calculating means 150 is designed to calculate this projected distance, thereby taking into consideration the limit distance d_{Gr} and information about the relative motion between the distance measuring device and the obstacle. In order to optimize the calculation, the limit time may also be taken into consideration.

The function of the distance detecting device 100 shown in Fig. 1 is described in detail below with reference to the embodiments of Figs. 2a, 2b, and 2c.

In order to illustrate the method, we assume that the vehicle 50 is travelling towards an immovable, i.e. stationary obstacle 200 at a speed

V (see examples of Figs. 2a through 2c). This is clearly only one particular kind of relative motion. Other relative motions include: only the obstacle 200 moves and the vehicle 50 does not move, or both the vehicle 50 and the obstacle 200 are moving. In Fig. 2, the installation height of the distance measuring device 110 above the road is designated with h_s . The point on the surface of the obstacle 200 having the shortest projected distance from the distance measuring device 110 is designated with P. The height of this point P above ground or above the road is designated with h_p .

Fig. 2a shows a situation, wherein the distance between the distance measuring device 110 and the nearest point P of the obstacle 200 is sufficiently large that the nearest point P is within the detecting range of the distance measuring device 110. Suitable distance information can then be easily determined, as originally envisioned.

As the vehicle 50 moves towards the presumably stationary obstacle 200 at a speed V, the nearest point P moves increasingly out of the center of the detecting range of the distance measuring device 110 until it finally lies on its border as indicated in Fig. 2b. In accordance with the invention, the time at which this situation occurs is called the limit time. The projected distance between the nearest point P and the distance measuring device 110 at that time is called limit separation. The detection and storage of these limit values is essential for the present invention, since when the nearest point P is no longer within the detecting range of the distance measuring device 110, the distance between the nearest point P and the distance measuring device 110 can only be calculated when these two limit values are known. The detecting range of most distance measuring devices is defined by the position and the opening angle of their radiation cone. When the portion α of the opening angle of the distance measuring device 110, which is below the

horizontal H , and the difference between the installation height h_s of the distance measuring device 110 and the height h_p of the nearest point P are known, the limit distance d_{Gr} at the limit time can be calculated according to the following formula (1)

$$d_{Gr} = \frac{\tan(\alpha)}{h_s - h_p} \quad (1)$$

A further approximation is obtained when e.g. the vehicle 50 continues to move towards the obstacle 200. This relative motion is shown in Fig. 2c in the form of the distance d_r which is determined by the distance determination means 140. The magnitude of this relative motion is of interest, in particular, starting from the limit time, at which the nearest point P of the obstacle 200 is no longer in the detecting range of the distance measuring device 110. The latter is indicated in Fig. 2c, wherein the nearest point P is no longer within the cone limited by the angle α . In the situation shown in Fig. 2c, the calculating means 150 calculates the projected distance d between the nearest point P of the obstacle 200 and the distance measuring device 110 in accordance with the invention through simple subtraction of the relative distance d_r from the limit distance d_{Gr} . This calculation method is valid irrespective of the speed at which the obstacle moves, after detection of its nearest point, completely out of the detecting range of the distance measuring device 110. This occurs sooner for narrow obstacles than for wide obstacles.

In case of wide obstacles (obstacle 200 in Fig. 2c), parts of the obstacle 200 are still detected even when the nearest point P is no longer in the detecting range. This is indicated in Fig. 2c, as the radiation cone of the distance measuring device 110 contacts the obstacle 200 on its upper surface at point B . An interpretation of the projected distance d_B of this point as being the shortest distance between the obstacle 200 and the

distance measuring device 110 would be wrong as is shown by a comparison with the correct projected distance d (also shown in Fig. 2c), and could result in an undesired collision between the vehicle 50 and the obstacle 200. The distance d is the actual shortest distance.

The above described and claimed method for detecting the projected distance between a distance measuring device 110 and an obstacle 200 in accordance with the invention is preferably realized in the form of a computer program which may run on a suitable computer, in particular, a microprocessor. The computer program may optionally be stored on a computer-readable data carrier together with further computer programs. The data carrier may be a disc, a compact disc (so-called CD), a flash memory or the like. The computer program stored on the data carrier may be transmitted and sold to a customer as a product. The computer program may also be transmitted and sold as a product to a customer without the aid of a data carrier, e.g. via an electronic communications network. The communications network may e.g. be the Internet.